

Study of Reverse Osmosis Process of Distillery Industry for Zero Liquid Discharge- A Case Study at SSK Plant, Nandurbar, Maharashtra

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Abstract: This paper highlights the use of Membrane systems in a wide variety of applications. Large industrial applications exist but majorly it is used on laboratory scale. Modular welded steel profile skid frames were built for easy installations which reduces the cost of operation and service. Continuous operation of the RO Plant results in building up of impurities such as salts, suspended/ colloidal and organic matter on the membrane surface which results in increase in operating pressure & the product flowrate drops. This phenomenon is called scaling/ fouling of membrane surface.

Keywords: Membrane systems, Membrane surface, Scaling, etc.

INTRODUCTION:

Membrane systems have been used for a number of years in a wide variety of applications. The vast majority of these uses have been of laboratory scale, although large industrial applications exist. One of the primary uses of membrane systems is the desalination of industrial waste water and brackish water. Other more difficult process streams have often been left to other technologies.

The lack of industrial applications is mainly due to the membrane holding systems. Conventional membrane systems are spiral-wound, hollow fine fiber, or tubular modules. Spiral Wound and hollow fine fiber modules require very high levels of pretreatment to prevent fouling and scaling, while the tubular module is too expensive for most applications. A development in membrane carrier systems, the Rochem PTRO & STRO overcomes the problems of previous modules. With the Rochem modules, membrane processing of a multitude of industrial streams is now feasible.

The application of the PTRO & STRO technology to a number of different industrial water treatment and waste streams. The economics and the removal efficiencies of the PTRO & STRO show how a wastewater was reclaimed for reuse, instead of being discharged or disposed off.

THE STUDY

Construction Materials & Specifications.

The system is built in modular welded steel profile skid frames for easy installations which helps in economical operation and service. The modular unit design simplifies the installation and enables flexible use of limited floor space. All the materials used are free of defects. The

equipment is fabricated with the highest standard of engineering, design and workmanship.

Following components are installed in a standard system.:

1. Pre-filter Pump (Client Scope)
2. Filter Pump
3. Sand Filters
4. Dosing Systems
5. Cartridge Filters
6. High pressure Pump
7. ST Modules
8. Inline Booster Pump
9. PT Modules
10. Servo Motor Control Valve
11. Diverter Valves
12. Cleaning System
13. Control Panel
14. Measuring Equipment's /Instruments
15. Intermediate Tank
16. Intermediate pump
17. Degasser
18. Permeate transfer pump
19. Permeate tank

Low Pressure Pipes:

The low pressure valves and piping system is corrosion proof and fabricated of PVC, flexible rubber hoses with a maximum pressure stage of 10 Bar and Permeate Piping PU 9/ PU 4 with a maximum pressure stage of 06 bar.

High Pressure Pipes:

The high pressure piping and fittings are fabricated of special steel, rein-forced high pressure flexible rubber hoses which are braided with special stainless steel wire with highest standards of corrosion resistance suitable for

operation in effluent water with a high salt content. The nominal DIN pressure stage is $P = 65$ bar.

OPERATING INFORMATION PLANT OPERATION

The Effluent water is pumped into the system by the pre filter pump at the inlet of the filter pump. The filter pump further ensures that sufficient pressure is maintained in the system for normal operation. The effluent water is filtered by the sand filters and the cartridge filters which remove the foreign suspended materials. The filtered water is pressurized by the high pressure pumps. The water passes over in the STRO and PTRO Modules. The high pressure is regulated by the servo motor control valve. About 50% water passes across the pure water side as RO permeate from all stages, and remaining water is discharged as drain. The entire operation of the plant is automatically controlled by a stored program in the microprocessor fitted in the control panel. The control panel houses all the electronics and the electrical circuits. The pure water is called as permeate water which is the output of the RO Plant is sent to the storage water tank.

PRESTART CHECKS

Following pre-start checks are to be carried out whenever the RO Plant is to be commissioned or it is being started after a gap of approx. 07 days or more since the last operation.

1. Module tie-rod end nuts must be tightened to 100 Nm torque.
2. Unobstructed free running of the electric motors of the intermediate transfer pump, permeate water transfer pump, filter, booster pump and high pressure pump must be checked by rotating.
3. Correctness of voltage and phases must be checked.
4. Position of all the valves should be in normal operation mode as shown in the flow chart and the valve position plate.
5. External feed water inlet, brine outlet and the permeate outlet valves if any must be kept in open position.
6. Cartridge filter elements must be in clean condition.
7. Acid anti scalant are charged into dosing tanks.
8. Ensure dosing rates are correctly calculated and set.
9. Ensure that there are no leaks in the feed inlet piping.
10. Check all Instruments. (i.e. Conductivity, Flow and pH meter).
11. Direction of rotation of pumps are correct.

DOSINGS

As per design of the system following dosings have been incorporated in the process:

1. Acid Dosing : Commercial grade Hydrochloric Acid (HCl) is to be dosed in feed to bring pH to optimum level for treatment process. Considering variable nature of the feed water due to parameters such as feed pH, Alkalinity, etc. it is recommended to maintain dosing of feed pH. 6.5 approx at all times. This can be achieved by using acid injector and also direct dosing in feed tanks in case of higher requirements.
Rate of dosing : This will depend typically on pH and alkalinity levels of feed. Adjust post dosing pH 6.5 approx.
2. Antiscalant Dosing : To avoid scaling due to potentially sparingly soluble species such as Calcium Sulphate, Silica etc. it is essential to dose antiscalant [ROHIB 28] Part No. 112310101001 into the feed at all times. This product helps to avoid scaling up to certain degree due to above mentioned species. Rate of dosing : As per system design a 3- 4 ppm (approx.) dosing rate is recommended at all times. Product may be diluted with RO permeate.

START-UP PROCEDURE

1. Open external feed / brine valves as applicable.
2. Set the valves to normal operation mode.
3. Ensure dosing systems are setup as required and bypass valve VS1602 is full open.
4. Switch on the electric supply with the rotary switch.
5. Press lamp button No.1 "START" (will keep blinking).
6. Pre-filter pump PK121 (client scope) starts automatically. After delay PK131 also starts. If PK121 is not connected with PLC, start PK121 from remote and press button no.1 "START" in control panel after delay of 2-3minutes.
7. Acid is dosed by the acid injector and then anti scalant dosing pump starts after time delay.
8. High pressure pumps PK1601
9. Inline Booster Pumps PK162 starts after delay time.
10. Again after some time delay inline booster pump PK 163 starts. Manual Globe Valve controls the flow in the stages. Then Bypass Valve VS1602 closes automatically.
11. Servo Motor control valve VS1601 closes, adjusts the module pressure to maintain the permeate flow at set flowrate.
12. The continuous conductivity monitoring meter CIS180 will display the conductivity. The high conductivity permeate is diverted to the drain, via solenoid valve, VE1803.
13. As the module pressure increases gradually, the permeate conductivity falls below $2000 \mu\text{S}/\text{cm}$ and the solenoid valve VE 1802 diverts the permeate water to the permeate tank.
14. The module operating pressure is controlled during

operation by the PT1601 & FIS180.

15. Within few minutes of the start up, the lamp button no. 1 stops blinking the moment the normal operating mode is reached. This is indicated by lamp button 1 remaining continuously 'ON'.
16. Close valve VK 1601 to maintain differential pressure 4 -5 bar between PI162- PI1621, also close valve VK1602. Similarly close VK 1603 to maintain differential pressure between PI163 -PI1631.
17. Electrically actuated valve VE 1603 & VE1604 will close automatically.

CIRCUIT CLEANING PROCEDURE

With continuous operation of the RO Plant the impurities such as salts, suspended/ colloidal and organic matter which are rejected tend to build up on the membrane surface. This results in first an increase in operating pressure, then a drop in product flowrate.

This phenomenon is called scaling/ fouling of membrane surface. In order to restore membrane performance it is important to regularly clean membranes by using Rochem cleaning solutions.

IMP: Carry out complete cleaning each time the flow drops by 10 -15 % from normal level, or once a week whichever is earlier with necessary intermittent flushes. Carry out cleaning in sequence of Membrane Cleaner 33, 22, 11 as required.

It might be required to carry out short cleaning during the week also. This depends on the salinity and the fouling on membranes which is result of sudden change in feed characteristics.

Full cleaning cycle with all the 3 cleaners may not be required at the time of short cleaning.

Solution	Qty. /Cleaning	Frequenc y	To be done when
Membrane Cleaner11HD	37Ltr	4 per month	At drop or weekly
Membrane Cleaner 22HD	37Ltr	4 per month	At drop or weekly
Membrane Cleaner 33HD	37Ltr	2 per month	Fortnightly

The circuit cleaning mode can only be started when the unit is running in normal operation mode. Sequence of cleaning procedure:

CLEANING - I RINSE CYCLE:

1. Press lamp button 3 "CIRCUIT CLEANING" and close valveVK111.
2. Lamp button 3 "CIRCUIT CLEANING" is flashing.
3. Permeate transfer pump PK195Stops.
4. Permeate tank fills up to high level LS182 & then pure water is diverted to cleaning tank B170 till it gets completely filled.
5. Servo motor control valve VS1601 opens after high level switch indication in cleaning tank to reduce operation pressure also VE 1603 & VK 1604 will open
6. Inline Booster Pump PK162 & PK163 stops after a time delay
7. Plant in shut off mode VE 1603 & VE 1604 will be open on rinsing & cleaning mode for more flushing.
8. Press the Start Button No.1 RO Plant runs for few minutes and rinses all the PT Modules with permeate water taken from permeate tank, until the water reaches level switchLS181.
9. The RO plant stops and Lamp no. 3 "CIRCUIT CLEANING" starts flashing, requesting for commencing the cleaning of the PT Modules.

CLEANING- II CLEANING CYCLE:

1. Press Cleaning button PK 131 will start
2. Cleaning solution is poured into the Cleaning Tank B170 with quantities as shown VK132 keep open when cleaning solution pour in the cleaning tank. After Cleaning closeVK132
3. VE1802 is diverted to cleaning tankB170
4. After pressing clean button PK131 starts then PK1601 starts after 15seconds.
5. PK162 & PK163 starts after specified time delay.
6. The RO Plant starts and cleaning cycle commences automatically. The cleaning solution from the Cleaning Tank B170 is circulated in the ST & PT Modules.
7. Cycle continues for 2hours.
8. When cleaning mode has finished (no buttons are illuminated) change valves back to normal operation position.
9. Open valve VK111 to drain cleaning tank.
10. Cleaning with the particular solution is now complete. Repeat the above procedure now with remaining types of solutions. Carry out repeated cleaning cycle if found not effective (It is an indication of greater than normal fouling). Rinse the system after every cleaning.

ISOLATION OF PTMODULES

In case of unsatisfactory performance of any ST & PT Module, it can be bypassed by, disconnecting the product water & by the high pressure piping from the affected PT Module. Bypassing of high pressure raw water feed of the affected PT Module is done as under. Plant must be stopped and feed water is to be shut off completely. Water pressure in the system should be released. High pressure flexible pipe is to be disconnected from the ST & PT Module. Both disconnected high pressure pipes is to be connected in series with a Module bypass nozzle. This maintains constant designed quantity of raw water feed supply to the rest of the operational modules. It also maintains designed product water supply from the individual ST & PT Modules. Product water pipe is to be 'disconnected' and 'blanked' at the common product water manifold. Do not connect HP flexible hoses from common inlet manifold to common outlet manifold directly. It may result in excessive draining of raw water. Do not blank off the raw water supply as it may result in excessive water supply to the operational modules and damage their membranes. Each module must be supplied with 800 ltrs/hr. (approx.) raw water feed to have the optimum performance. All raw water should be drained off from the defective module and this module should be preserved by adding 250 ml of Membrane Solution 44 to 4 ltrs of product water from the plant and mix it thoroughly. This solution should be filled completely into the defective ST & PT Module from the raw water inlet by inverting the PT Module in vertical position and all the inlet and outlets are plugged or capped. Alternately module can be kept horizontal and preservative can be pumped into it.

CLEANING AND ARRESTING LEAKAGES

The Plant and its surroundings must be kept clean, free of dust/ dirt/ salt deposits etc. The Operator should look for following while undertaking daily maintenance.

1. The RO PT Modules pressure vessels have at either ends exposed internal surface beyond the Groove ring. If this surface catches dirt / dust then there is a chance of this dirt finding its way to Groove ring sealing area and cause Groove ring leakage. Continual un-cleanliness of this area can cause damage to Groovering.
2. The control components such as Solenoid valves, Servo Motor valve, Conductivity meter should be free from dirt and water spillages.
3. Control Cabinet door should be kept closed to prevent dirt / dust / water from entering inside. The daily check and in time correction safeguards the vital components and keep plant in efficient working condition avoiding premature break down.
4. Check for leakage from any pipe connection and tighten to stop leakage.

OPERATIONAL LIMITATIONS:

The operational limitations of this RO Plant are asunder:

1. It will not come in normal operation unless and until the Raw water (Effluent water) inlet pressure at HP Pump inlet is above 01 bar. This is sensed by the PS151. In case the inlet pressure is lower than 01 Bar the RO Plant will not come in normal operation or will trip giving an indication of Raw Water shortage.
2. The RO Plant is designed for performance at a maximum raw water conductivity of 2000 $\mu\text{S/cm}$ max and will produce only 200 m³/day of RO permeate water

REFERENCES:

- Technical Manual regarding waste water treatment system of Shree Satpudatapi Parisar Sahakari Sakhar Karkhana Ltd, Nandurbar, Maharashtra